Tetralogy of Fallot: Management Review

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Tetralogy of Fallot is the most common cyanotic congenital heart malformation encountered at the National Institute of Cardiovascular Diseases (1) Majority of patients at presentation are either severely cyanosed or have significant exercise intolerance. A goodly number present with hypercyanotic spells (2). The age at presentation ranges from infacy to adulthood. Because of the wide spectrum of presentation in all age group it had imposed a great demand on our developing invasive paediatric cardiology services. The purpose of the present study was to review the 'progress' of children who were seen either at the paediatric out-patient clinic or admitted to the in-patient service at the National Institute during 1980-1983 period, and to review our diagnostic medical and surgical service management capabilities. Finally the purpose was to determine future needs and directions of paediatric cardiology services.

Material and methods:

Three hundred and twentyeight patients were included in the study.

These children were seen at the paediatric out patient clinic or admitted to the children's ward at the institute, from October 1980 to December 1983. The hospital charts of all the patients were reviewed in October 1985 in order to evaluate the course of each patient. Clinical examination and investigations of each clinic visit were recorded on a separate examination sheet. Electrocardiogram and chest X-ray were routinely obtained in all patients. The follow up of each patient was concluded at the last clinic visit but prior to October 1985.

The diagnosis was confirmed by cardiac catheterization in all patients who underwent complete intracardiac repair, and during earlier period, even in those who had shunting operation. After the introduction of two dimensional echocardiography we confirmed the anatomic diagnosis by echocardiography imaging only. Thus 144 of 328 patients (43.9%) had cardiac catheterization and 133 of 328 patients (41.9%) underwent two dimensional sector scan echocardiography. Most patients who had cardiac catheterization and angiocardiography also had echocardiography. Patients who presented with hypercyanotic spells were treated with oral propranolol (Inderal) in 1-3mg/kg divided daily dose up until the day of surgery which was performed electively (3). Children who were administered propranolol were followed closely in the out-patient department with 1-3 monthly visits.

The criteria for treating recurrent cyanotic spells with prolonged propranolol, were, a cardiac murmur of no less than grade 2/6 and haemoglobin of less than 18-19G per cent. All children having haemoglobin of greater than 20G per cent and cardiac murmur of less than grade 2/6 were operated at the first available opportunity. Patients in whom spells recurred while on propranolol, were admitted in the hospital and in most cases shunting operation was performed.

Surgical palliation was done by performing a systemic to pulmonary artery shunting operation usually by inseting a Gore-Tex graft between the subclavian artery and pulmonary artery usually on the right side because right pulmonary artery could be confidently imaged by two dimensional sector scan echocardiography and confluence to the left pulmonary artery could be imaged in most patients. Those patients in whom pulmonary artery was not adequately imaged by echocardiography underwent cardiac catheterization. Complet correction was undertaken after the age of 4 years of at more than 15 kg body weight,

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provided pulmonary arteries and left ventricle were of adequate size (2). Younger children who had recurrent hypercyanotic spells all underwent shunting operation.

Results:

Tow hundred and ninetyeight of 328 patients were less than 14 years age and 20 patients were greater than14 years (mean age 17.5 ± 3 years) at the time of presentation. In 10 of 328 patients ages were not known. Fiftyeight patients were less than 1 year of age, mean 0.6 ± 0.3 years, and 240 patients were between 1-14 years age, mean 6.4 ± 3.7 years, Table. I.

TABLE I

AGE OF 328 PATIENTS WITH TOF

Age (year)	N	%
Less than 1 (0.6 ± 0.3)	58	17.7
More than 1 (6.4 ± 3.7)	240	73.2
More than 14 (17.5 ± 3)	20	6.1
Age not known	10	3.0
	328	

Ages are not precise, the data is based on parents recall.

It may be noted than the age estimates in younger patients are likely to be more accurate since recall of the parents was the source of information. Precise birth dates were not recorded by majority of parents. The mean age for the entire group was 6.2 years, range 20 days to 24 years. There were 15 infants less than 2 months of age at the time of presentation. Males (220 of 328 patients) dominated the series and were approximately twice in number compared to the female patients (108 of 328). The mean haemoglobin value for the 203 patients, in whom data was available, was 19.0 ± 4.0 G per cent. One hundred and fiftyeight children were seen at presentation with hypercyanotic spells. The mean age of children with spells was 3.6 years, range 20 days to 12 years. The degree of clinical cyanosis was evaluated as mild (grade I) in 138 patients, (42.1 per cent) moderate (grade II) in 91 (27.7 per cent) and severe (grade III) in 99 patients (30.2 per cent). In 67 older children exercise intolerance of severe degree, i.e., inability to go out of the house, was noted in 33 (49.3 per cent). Moderate degree of exercise incapacity implied inability to attend school or manage one flight of stairs was present in 29 children (43.3 per cent). Five of 67 patients (7.5 per cent) had mild incapacity so that these children were able to play and attend school but were unable to participate in school games or keep up with their peers.

The mean weight of patients who had shunting operation was 11.3 ± 7.3 kg (3-4 kg) and for 19 survivors of shunting operation the mean weight was 10.4 ± 0.37 kg which was not significantly different than 47 survivors whose mean weight was 11.6 ± 7.4 kg. The body weights were recorded in 82 patients who had undergone total correction and the man value was 25.3 ± 12.0 kg. The weight of 14 nonsurvivors of total correction group was 22.6 ± 0.9 kg compared to 26.1 ± 12.5 kg for 70 survivors.

Follow up results:

One hundred and sixtytwo children were treated medically. One hundred and twentytwo of these children were greater than 1 year of age at the time of presentation, mean age being 5.6 ± 3.3 years and 40 infants were less than 1 year of age, mean 0.6 ± 0.3 years. Sixtyfive of 162 children (40 per cent) were only once in the clinic and were assumed lost to follow up. Eighty of 162 children were known to be alive (49.4 per cent) and their mean follow up period was 14.7 ± 12.3 months. Seventeen of 162 children have died, a mortality of 10.5 per cent, Table II.

TABLE II

MEDICAL FOLLOW UP (MFU*): TETRALOGY OF FALLOT 1980 - 1985

	N
Seen once (lost of FU)	65
Survivors (known)	80
Non survivors	17
*MFU (14.7 ± 12.3 M)	162

TABLE III

CAUSES OF DEATH ON MEDICAL FOLLOW UP 1980 - 1985

	N
Hypercyanotic spells (Presentation)	8
Hypercyanotic spells (On Inderal)	4
Brain abscess	3
Cerebral thrombosis	2
	17

The causes of death on medical follow up was hypercyanotic spells in eight children in whom it was the presenting symptom. In 4 children death occurred while they were being treated with propranolol for recurrent spells. Central nervous system complications, such as brain abscess in 3 and cerebral thrombosis in 2 accounted for the remaining deaths, Table III. The mean age of these 17 non-survivors was 3.5 ± 3.4 years and the duration of medical follow up in 8 of the 17 patients was 3.2 ± 3.1 month. One baby was 20 days old at the time of death and 8 patients were only seen once. Four patients who were taking propranolol and died were 2.5 ± 3.0 months of age at the time of death.

One hundred and fiftyeight of 328 patients (48.2 per cent) presented with hypercyanotic spells. The mean age was 3.8 years range. Seventysix children (48.1 per cent) were treated by surgery and 82 patients (51.8 per cent) were followed medically.

TABLE IV

DATA OF 32 DEATHS WHO HAD SPELLS, TOF 1980 - 1983

	N	Age (years)
Medically treated	12	3.2 ± 3.4
Surgically treated	20	3.8 ± 3.6

The mean age of surgically treated patient with hypercyanotic spells was 4.0 ± 4.4 years and 3.6 ± 3.3 years of those treated medically. Twenty-six of seventysix patients (26.3 per cent) who were treated surgically and 12 of 82 (14.6 per cent) who were treated medically died. Thus 32 of 158 children presenting with cyanotic spells died, an over all mortality of 20 per cent. Seventysix children were treated with prolonged maintenance propranolol to prevent recurrent cyanotic spells for a mean duration of 0.99 ± 1.2 year. Seventyone children were treated for 1.03 ± 1.02 years and 5 infants had propranolol for 2-11 days only. Of the 76 patients, who had propranolol for prevention of recurrent spells, 40 patients underwent surgical procedure. The mean duration of propranolol administration prior to surgery was 0.99 ± 0.95 years (range 1 month to 3 years). Ten of these died from surgical procedures. Eighteen patients had complete correction with 4 deaths and thirtysix patients had shunting operation with six deaths. Thirtysix of 76 patients were only treated medically with propranolol till the conclusion of the study.

TABLE V

FOLLOW UP OF 158 PATIENTS PRESENTING WITH CYANOTIC SPELLS TOF, 1980 - 1983

	Age	N	Mortality N	Mortality %
Surgically treated	4.0 ± 4.4	76	20	26.3
Medically treated	3.6 ± 3.3	82	12	14.6

One hundred and sixtysix of 328 patients were treated by surgical means, thirtyeight (22.2 per cent) died and 128 patients survived surgery, Table VI. The age of presentation was 7.6 ± 5.1 years. The mean age of non survivors was 6.4 ± 4.4 years compared to mean age of 8.09 ± 5.3 of 128 survivors. Table VI

Seventyfive children (mean age 4.6 ± 4.4 years) had shunting operation and 91 children (mean 10.4 ± 4.4 years) had complete correction involving closure of ventricular septal defect and resection of right ventricular infundibulum by using cardio-pulmonary bypass technique. Twentytwo of the 75 children undergoing shunt operation died, (29.3 per cent mortality). The

TABLE VI

FOLLOW UP 166 SURGICALLY TREATED TOF PATIENTS, 1980 - 1983

	N	%
Non Survivors	40	24.1
Lost of follow up	85	51.2
Alive on follow up (13.9 ± 12.5 M)	41	24.7
	166	

mean age at death was 4. 9 ± 4.5 years compared to 5.9 ± 5.3 for 53 survivors. Sixteen of the 91 children undergoing complete correction died, a mortality of 17.6 per cent. The mean age of 91 complete correction group was 10.4 ± 4.4 years. The average age of 15 non-survivors was 9.2 ± 3.9 years compared to mean age of 10.6 ± 4.5 years for 73 survivors, Table VII. Eleven of 91 children who underwent total correction were taking propranolol for the prevention of recurrent hypercyanotic spells, three of these died compared to 13 deaths among 72 patients who were not taking propranolol at the time of operation, statistically a non-significant difference.

The cause of death due to surgery could be analysed for the entire population. Among the shunting group most common cause was non-function shunt and in seven instances due to technical difficulties a shunt could not be instituted because pulmonary arteries were considered to be too small (4-6mm on two dimensional echocardiogram). In the total correction group the cases of death included intraoperative deaths, post-operative bleeding, low cardiac output syndrome, problems with mechanical ventilation, sepsis, post-operative jaundice and serum electrolyte disturbances due to fluid mismanagement.

The progress of 128 surgically treated survivors was analysed. Eightyfive (67 per cent) of these were lost to follow up after discharge from the hospital. Fortyone of 128 patients (32.5 per cent) had been followed or a mean duration of 13.9 ± 12.5 months, Table VI. The post surgical clinical and functional assessment results have previously been reported for this group. Forty children (24.1 per cent) died, 38 died immediately after surgery and, two patients had late deaths, both in shunting group of patients, probably due to closure of the shunt, Table VII. There were few significant post-operative complications in 41 survivors. Four children had permanent pacemakers and 2 patients developed nonfunction shunts after 6 months and 2 years respectively. The functional stutus of all children who had palliative surgery had improved. The outcome of 15 infants less than 2-month of age showed that there were five deaths, 4 surgical and one medical with a mortality rate of 33 per cent.

TABLE VII

DATA OF 38 SURGICAL NON SURVIVORS

	Age (years)	N	%
Age at death	6.4 ± 4.4	38	
Patient on Inderal	3.7 ± 3.9	11	28.9
Without Inderal	7.3 ± 4.6	27	71.0
Total Correction	8.9 ± 4.3	16	42.1
Shunt Operation	3.9 ± 3.1	22	57.9

In summary the analysis of the outcome of 328 patients with tetralogy of Fallot showed that 65 (19.8 per cent) patients who were on medical treatment, were lost to follow up, and 85 patients (25.9 per cent) who had undergone palliative or corrective surgery did not return to the follow up clinic at the NICVD since majority of these were referred to the NICVD from Northern provinces, Table VIII.

TABLE VIII

TETRALOGY OF FALLOT, FOLLOW UP; 1980 - 1985

		N	%
Non-Survivors		57	17.4
Surgical	38		
Medical	17		
Late (Surgical)	2		
Survivors		206	62.8
Medical	80		
Surgical	26		
Lost of Follow up		65	19.8
		328	100.0

Fiftyseven patients died (17.4 per cent), 40 from surgical intervention and 17 from medical causes. There were 121 (36.9 per cent) known survivors with follow up at the NICVD 80 are being treated medically and 41 had undergone surgery. Seventysix children (31.9 per cent) are administered propranolol for the prevention of recurrent spells. Seventyone children were followed on propranolol for a mean duration of 1.03 ± 1.02 years. Five children were given inderal for 2-11 days only. In 40 of 76 children surgery was undertaken electively after a mean duration of 0.99 ± 0.95 years (range 0.08 — 3 years).

Thus of 328 registered patients over the three-year period, 271 (82.4 per cent) survived, including 65 patients who were alive at the last examination but are lost to follow up and fifty-seven patients (11.4 per cent) had died. One hundred and twentysix patients (38.4 per cent) survived surgery with greatly improved exercise capacity and 145 (44.2 per cent) survived medical follow up until the time of observation, Table - VIII

Discussion:

Analysis of the incidence of various types of heart diseases in children has shown that tetralogy of Fallot is the second most common congenital cardiac malformation encountered at the National Institute of Cardiovascular Diseases, at Karachi (1). Thus paediatric cardiology service management needed to be appropriately modified and expanded to meet the demands of this group of patients. Our date showed that majority of patients who were seen at the cardiovascular institute were significantly symptomatic so that majority of children required surgical correction. Since the patients age ranged from a few days old to adolescence, full range of paediatric cardiac surgical and medical facilities needed to be developed in order to take care of all age groups. Our present surgical set up in not separate for paediatric patients, the service capabilities were of necessity geared towards management of older children and infants requiring surgery were either treated medically or underwent palliative surgery. Of late the results of palliative shunting operation and complete correction have improved. At the present time the minimun age and weight for successful complete correction is 4 years and or 15 kg body weight respectively. Children weighting less than 15 kg do not fair well with complete correction operation so that infants who require surgery because of cyanotic spells or severe cyanosis undergo palliative shunting operation (2).

The results of shunting operation in infants less than 3 months of age need considerable improvement. In the past only few shounting operations were performed during the new born period. The lack of satisfactory surgical outcome in infants was due to the fact that adequately trained paediatric intensive care team of nurses and paramedical personnel were not available. A cardiac surgeon who is specially interested and trained in paediatric cardiac surgery is essential for the development of infant surgery programme. The newborn and infant surgery is very demanding and extremely intensive care orientated. It requires significant number of specially trained senior nurses highly motivated and adequately compensated.

Our surgical results showed that surgical intervention had not significantly altered the survival rate when compared to medically treated patients, thus our present effort had not essentially changed the natural history of survival for children with tetralogy of Fallot. This is not to say that modification in the natural course of the disease has not occurred. Those patients who have survived surgery are now either free of symptoms of cyanotic spells or exercise intolerance and are functionally normal and the annual expected attrition rate of surgically untreated, tetralogy of Fallot has been largely eliminated (4). The surgical palliation or correction was possible in only half of the patients and the remaining half are awaiting surgical repair.

Our present surgical service would have to be expanded to meet this additional demand. In Pakistan cardiac centres are rapidly being developed in other parts of the country. It is hoped that paediatric cardiac services are developed in concert with adult cardiac services or preferably separate paediatric cardiac facilities would be developed which would be properly staffed with trained personnel.

Our initial results of surgery are commendable. The mortality is high but is consistent with results

of early surgical experience of major cardiac centres round the world (5-6). The experience has shown that when infrastructure of specialized medical and surgical services is in place then the surgical results improve with succeeding years (5). This indeed was reflected in our data.

Surgical correction of tetralogy of Fallot provides a definitive treatment. Our data had shown that with our present facilities we could only provide total correction to only 28 per cent of children. For the remaining we are forced to follow them conservatively or undertake palliative surgery. This is particularly true of infants who are having cyanotic spells. We reported our pilot experience with propranolol and showed that it was effective in controlling the recurrent cyanotic spells (3).

Thus we treat all infants and older children who are experiencing cyanotic spells with propranolol on long term basis. This provides opportunity to undertake elective surgery in these children. We have learnt to avoid long term use of propranolol in severely cyanotic infants who have markedly attenuated systolic murmur. Non-compliance of propranolol medication by parents remains the major drawback of this therapy and may adversely affect a significant number of infants and children who are lost to follow up. Only four of 76 infants on continuous propranolol therapy, and who returned to the clinic died. Thus in our setting the medical management of recurrent cyanotic spells with oral propranolol is a practical necessity since all of the infants seen with cyanotic spells can not be managed by surgical means.

There was mortality of 10.5 per cent among patients who were followed medically. Majority of these deaths however were due to hypercyanotic spells which was the presenting symptom so that mortality on follow up with conservative management was only 5.5 per cent. It seems. therefore relatively safe to follow children on medical management till the time when elective surgery can be performed. The great danger with this approach is that significant number of children may be lost to follow up and as our experience has shown these children, who are lost to follow up, return when they are desperately sick.

Our data has shown that approximately one child in five is lost to follow up and a greater number, that is one in four children, who had palliative procedure is lost to follow up. This degree of failure to completely with management protocol has posed a major logistic problem. We have made special effort to explain the nature of malformation to all the patients particularly those who are on propranolol or who have had palliative surgery so that return visits are ensured. A great number of children are referred to the National Institute from upcountry and a great majority are desperately poor. Thus the non-compliance is not only due to lack of education or care but constraints imposed by proverty. This highlights the problems of structured programmes in the Third world which for financial or manpower constraints cannot meet the demands of imposed on them.

In summary our study has brought the problems of management of this group of children and has radically affected our management policies. It has brought home to us the realization that infrastructure of paediatric cardiology must be built. A great deal of love, care and dedication is required if we are to care for our children.

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